Boeing 777 Thrust Reference Setting Anomaly.

There is a software anomaly in the Thrust Reference Setting system on the 777. This anomaly manifests itself on most flights, but goes un-noticed by the operating crew and has little impact. However during an engine out, VNAV NPA approach, this anomaly could well result in a low speed excursion without appropriate auto throttle response.

FCOM 04.20.16 "Automatic Flight – System Description" / "Go Around"

TO/GA arms and the reference thrust limit changes to GA when the flaps are out of UP or glideslope is captured.

Background.

The thrust reference setting is annunciated at the top of the EPR/N1 gauge and can be changed through various methods (FMC Thrust Lim, FLCH, VNAV, CLB/CON etc). This setting limits the maximum thrust that can be applied through the auto throttle. It does not affect thrust that than can be applied manually through the thrust levers - TO/GA thrust always remains available, if the pilot pushes the thrust levers forwards (whether the A/THR is engaged or not), full TO/GA thrust will be achieved.

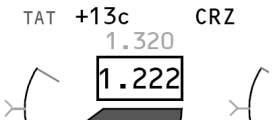
When Flaps are extended, or glide slope capture achieved, Thrust Reference is set to TO/GA. This can be verified above the EPR/N1 display and on the FMC Thrust Lim page. This is done by the AFDS/FMC with the intent of providing full TO/GA thrust while in the high drag approach/landing configuration, should it be required.

However it has been noted that once TO/GA has been set, subsequent operation of FLCH sets CLB Thrust Reference (or CON when engine out) and the engagement of VNAV sets CRZ (irrespective of engine configuration). During two engine operation, this has little or no impact on flight operations as CRZ thrust is sufficient for normal operations. Note that at any point GA thrust limit can be set through the FMC Thrust Lim page.

Flight Safety Impact – Scenario Description.

Assume a 777 at maximum landing weight, approaching the final approach fix (FAF) on an Engine Out NPA. The crew intend to use VNAV for the approach, but are achieving initial approach altitude using Basic Modes (FLCH / VS). Standard profile for an engine out VNAV NPA approach has the aircraft inbound to the final approach fix, level at initial approach altitude, Flaps 5. If basic AFDS modes were used to achieve this, thrust reference will be either GA or CLB/CON, depending on whether FLCH was used after Flap Extension (see previous).

At 2 nm from the FAF, Gear Down/Flaps 20/Flap 20 speed is selected. Thrust levers retard to slow the aircraft to Flaps 20 speed. Meanwhile the PF will set the minima in the altitude select window on the MCP, check track, engage VNAV PATH and speed intervene. If FMC entries were appropriate, VNAV speed target will be Flaps 20 speed (as was manually selected).



With the engagement of VNAV PATH, CRZ thrust reference is set. As the aircraft approaches Flap 20 speed, thrust levers move forwards in anticipation of achieving speed stability (giving the PF the tactile feedback expected), but thrust is now limited by CRZ thrust. Typically at maximum landing weight, CRZ thrust is insufficient to maintain speed, but enough to prevent a speed trend indication. Speed will now continue to reduce until descent commences, PF overrides the auto throttle, or an increase thrust limit is set. At minimum manoeuvring speed, low speed protection would normally be available (minimum speed or eventually auto throttle wakeup), but this protective feature is limited by the CRZ thrust limit setting. The only low speed protection (through the autopilot) that will function is stall protection as the aircraft approaches stick shaker speed.

Prior to a low speed excursion and stick shaker activation, the problem can be corrected by selecting GA through the FMC Thrust Lim page or pressing the CLB/CON switch (CON thrust limit only will be selected) – or simply pushing the thrust levers forward. CON thrust should be enough to maintain speed at maximum landing weight. Higher weights may require more thrust.

Notes

- On an ILS approach, FLCH may have set CLB/CON after flap selection, but glide slope intercept will reset TO/GA.
- TO/GA switch FMA mode activation sets GA thrust, so GA thrust limit is set during all go-arounds.
- Flap extension beyond 22.5° sets GA thrust limit.
- This anomaly does not impact on other NNM procedures (such as Windshear and GPWS). These recalls require either TO/GA Switch activation and/or manual thrust.